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THE IMPACT OF COMPUTERS ON KNOWLEDGE INDUSTRIES: PART I*

Charles A. Myers

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**Comments are welcome on this first draft, Part I.

ERRATA

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Page	
66	out of order, follows page 68.
11	Paragraph 4. line 4, first word should be Symposium
20	Paragraph 3. line 3, change "Daday System" to Data Systems
23	Paragraph 2. line 4, change "cost of \$0 to \$50" to cost of \$40 to \$50
27	line 6, "dange" should be danger footnote 3, line 3, last two words are essay grading,
43	Seven lines from bottom, in quotation from Conference Report, last word "multi-state" change to multi-stage
51	Footnote 1, change to read: See Appendix M, "How Humanists Use A Library,"
59	Paragraph 5. line 7, should read "has set forth....."
69	Line 9, change to -- to influence ....
74	Line 8, eighth word, change to instant

THE IMPACT OF COMPUTERS ON KNOWLEDGE INDUSTRIES

In less than two decades, the number of computers in use in the United States has increased from around 100 in 1955 to close to 50,000 today, with many more on order by expectant users.[1] The power and capabilities of modern computers, furthermore, are far greater than the "first generation" machines first used in limited applications. While the computer revolution has been spreading around the world, particularly in Western Europe, the Soviet bloc, and Japan, the American experience is far in advance of most countries, and suggests probable future applications in other world areas.[2] This is particularly true for the less developed countries which tend to borrow modern technology from advanced countries, especially through joint ventures.

Perhaps the great impact of computers in this country, as well as in other technologically-advanced countries, is in the management of enterprises. The literature on this experience is voluminous and growing.

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[1] Estimates obviously vary. The figures cited were used by the Bureau of Labor Statistics in 1967, and 80,000 computers were forecast for 1975. But a different estimate has been used by Edward J. Brenner, U. S. Commissioner of Patents: 60,000 by 1970 and 85,000 by 1975. "Computer Software Unpatentable," New York Times, October 23, 1968, p. 59. A recent IBM advertisement stated: "Fifteen years ago there were a handful of computers. Today there are more than 60,000 in use. And today's most advanced computers are about 1,000 times faster and process information about 100 times cheaper than the one (IBM delivered) in 1953." New York Times, December 29, 1968.

[2] An estimate as of December 1967 put U.S. "computer power" at 39,500, West Germany (3,500), Japan (3,000), Britain (2,800), France (2,200), U.S.S.R. (1,750), and China (mainland - 2,530). These are obviously rough data. Newsweek, January 29, 1968, p. 57.

Even recent evaluations tend to get out of date, as improved technology ("hardware") and associated programs ("software"), along with management science techniques, are improved and gain broader acceptance by management. Nevertheless, it is useful to stand apart from the specific applications, and raise questions about the broader implications of computers on organization structures, the nature of work, the resistance to change, and the means of gaining acceptance of the new technology. This was the objective of an earlier research effort in the Industrial Relations Section of the Sloan School of Management,[1] and of subsequent studies and research conferences to assess the impact of computers on job-man matching systems[2] and on collective bargaining.[3]

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[1] Charles A. Myers (editor), The Impact of Computers on Management, The M.I.T. Press, 1967, and Myers, "The Impact of EDP on Management Organization and Managerial Work," Working Paper 139-65, Sloan School of Management, M.I.T., September 1965. This work was supported by a grant to the Sloan School from the Ford Foundation, and the research conference had a supplementary grant from the International Business Machines Corp.

[2] Frazier Kellogg, Computer-Based Job Matching Systems, multilithed summary proceedings and report of a conference held at M.I.T. in January 1967. The conference was funded by a grant from the Office of Manpower Policy, Evaluation and Research, U.S. Department of Labor, and the research was supported from the grant by the Ford Foundation to the Sloan School of Management. A subsequent monograph by Frazier Kellogg, Computer-Based Aids to the Placement Process, was published by the Industrial Relations Section, Sloan School of Management, M.I.T., in February 1969.

[3] Abraham J. Siegel organized the research conference on the impact of computers on collective bargaining, which was held at M.I.T. in April 1968. A book with the papers and edited discussion is scheduled for publication by the M.I.T. Press in 1969. The conference was financed from the Ford Foundation grant.

The present paper is an assessment of the experience with computer applications in some of the "knowledge industries," exclusive of the fields already listed above. Defining the knowledge industries is arbitrary; a very broad definition would include much more than formal education.[1] I have chosen to limit my analysis of computer impacts to the following industries or areas:

1. Formal education, including the administration of educational institutions.
2. Library systems and sub-systems.
3. Legal and legislative services; administration of justice; crime prevention and law enforcement.
4. Medical and hospital services.
5. National (or regional) data banks for research and administrative uses.

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[1] See Fritz Machlup, The Production and Distribution of Knowledge in the United States, Princeton University Press, Princeton, New Jersey, 1962. Machlup includes as part of "education" the mother's education of children in the home, church schools, on-the-job training, education in the armed services, and libraries. But even this broad definition of education fails to encompass all of the knowledge industry, in Machlup's definition. Research and development, printing and publishing, broadcasting, movies and the theatre, information machinery, professional services, and telephone and telegraph were part of the "production and distribution of knowledge." All of this totaled $136 billion or almost 30 per cent of the GNP in 1958. For a later updating of Machlup's figures, see Gilbert Burck, "Knowledge: The Biggest Growth Industry of Them All," Fortune, vol. LXX, no. 5, November 1964, pp. 128-131ff. This article claimed that "the knowledge industry" a 43 per cent growth in the preceding five years.

The omissions from this limited list will be apparent to the reader. Non-academic training methods which rely on computer-aided instruction are similar to CAI in formal education. Consequently, they are omitted to avoid duplication. Research in science, engineering, social sciences and even in humanities, which has benefitted from the computational prowess of digital computers as well as from their capacity to permit rapid simulations, is not included, simply because the task of reviewing this "experience" is too great. Clearly, advanced econometric techniques used in economic forecasting, such as the Brookings model or the University of Pennsylvania model, would have been impossible without digital computers. Many other examples could be cited; but "research" as such is not included as a "knowledge industry," since it takes place in many different organizations - not simply in formal educational institutions.

Unlike the research on the impact of computers on management, which included field studies of the impact in a number of insurance companies as well as in several industrial firms, this study draws largely on a variety of scattered published and unpublished reports on experience with computer applications in the five knowledge industries or areas listed above. The bibliographic search and collection was conducted principally between June 1967 and September 1968, although the materials are being updated as much as possible.[1] The difficulty of keeping current is great; new developments continually occur. But a cut-off point is inevitable: January 1, 1969.

[1] This search and collection was the work of my graduate assistant, Ephraim R. McLean 3rd. He also conducted some interviews, and reported on several meetings and conferences; but most of the material consists of clippings, journal articles, published reports, unpublished memoranda, and other literature references.

In the sections which follow, each dealing with one of the five "industries" listed above, the available materials have been organized around some central topics and themes, with particular emphasis on the implications of computers for the organization of work, for the nature of jobs, and for the people affected. An important questions is: what is the evolving nature of man-machine relationships? These are the general themes, but they are preced in each section by a review of the following more specific points:

1. What were the needs which computer applications were intended to meet?
2. What were the first applications, and who were the pioneers? What were the early problems which had to be overcome?
3. What have been the more recent applications of computers, by initiating individuals or groups, by topical areas, and by geographical location? What problems have been encountered?

But the central questions, to repeat, are: What are the implications for each industry? How do computers affect — and are likely to affect — the nature of work, the ways in which it is organized and re-organized, and the man-machine relationship? What is the reaction of people affected by the new or potentially new relationship? Indeed, these implications for the present and the future are the most significant part of this report, and they are likely to raise the most questions among specialists. Just as there is disagreement about the ultimate implications of computers for management, so there may be challenge to some of the conclusions here.

Present or short-run potentialities may be different from the long-run vision. It is as important to specify this difference here, as it is for critics to be specific about their time horizons and other assumptions. One specialist concerned with the impact of computers on education has indicated the difference made by this time horizon:

> "I am manic-depressive about the future of educational technology: manic about the long-term possibilities which are extraordinary, and depressive about the short-run. No significant changes in the American education system during the next decade will be the direct result of current experiments with computers in education. It will take twenty or thirty years to overcome the social, economic, and technical factors that are retarding the use of computers in education."[1]

In other words, human factors as well as economic calcuations need to be considered in evaluating the potential of man-machine sytems. Technological feasibility may well be quite different from an operating system involving people. For example, the possibility of "artificial intelligence" draws nearer as man's thinking process is understood better and replicated in computer systems. But not even those who say that eventually computers can do everything man can do (or <u>almost</u> everything) would predict the eventual replacement of man by machines. The principle

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[1] Anthony G. Oettinger, speaking at the opening M.I.T. Seminar on educational technology, Spring term, 1968, as reported in <u>The Technology Review</u>, April 1968, p. 50. See also Oettinger, "A Vision of Technology and Education," <u>Communications of the ACM</u>, July 1956 (reprinted by the Harvard University Program on Technology and Society, Reprint No. 1).

of comparative economic advantage, if nothing else, will mean the likelihood of man-machine systems for the indefinite future.[1] The discussion below will indicate other reasons why these systems will continue in knowledge industries for a very long time, in an evolutionary rather than a revolutionary sense.

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[1] Herbert A. Simon, The New Science of Management Decision. New York: Harper & Row, Publishers, 1960, pp. 33-34.

Chapter 1

Formal Education and Educational Administration

Education is clearly the leading "knowledge industry."[1] Student enrollments have expanded at all levels each year, and investment in educational plant and equipment is mounting. But, for the most part, education has not been capital intensive in the usual sense; expenditures are primarily on salaries and services, real estate, buildings, furniture, and books. Some technological aids have been used, primarily audio-visual aids and programmed instruction, as in language laboratories. But when the Subcommittee on Economic Progress of the Joint Economic Committee considered the implications of computer-aided instruction (CAI), it concluded:

> "The prospective increased use of expensive communication equipment and systems involves much greater capital investment in equipment, and the employment of technicians to install and maintain it. This is a new phenomenon in the field of education. Educators who think primarily in terms of operating costs for classroom teaching will be required to change their accounting notions to accommodate certain fixed costs for instructional equipment to be amortized over time."[2]

While the future possibilities of technological-breakthroughs in education, through CAI principally, are unlimited, the present reality is quite different. The sharp contrast between the short-run and the long-run

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[1] Clark Kerr put it this way: "The American economy was built around railroads in the last half of the 19th century, around the automobile in the first two-thirds of this century, and it will be built around education in the balance of this century." Quoted in Report of the Subcommittee on Economic Progress of the Joint Economic Committee of the Congress, Washington, D. C., August 1966, p. 7

[2] Ibid., p. 8

(20-30 years) was succinctly expressed last year by Anthony Oettinger of Harvard in the statement quoted in the introduction to this paper.[1] Others agree with his diagnosis:

> "Although computer-aided instruction has served well as a research and demonstration tool, it is still in its infancy. It has not yet become a practical instructional tool ready for widespread implementation in public schools; indeed most of the problems that must be solved prior to its widespread application have yet to be solved. However, the rate of development of on-line computer usage for individualized instruction is very rapid and deserves serious attention by school planners."[2]

> "There is little evidence to show that the computer will find a substantial market as a teaching machine for at least five years, and more likely for 10 or 15. Much research remains to be done. Projections through 1970 for the market for 'electronic and related equipment' in all schools is $7.5 million, as compared with $5.5 million in 1965. Computer-

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[1] Supra, p. 6. However, "Oettinger's pessimistic conclusions....were disputed by a number of conference participants," Way e H. Holtzman, "Conference on Computer-Assisted Instruction, Testing, and Guidance," University of Texas, October 21-22, 1968, Items, vol. 22, no. 4, December 1968, Social Science Research Council, New York, pp. 43-48. For a restatement of Oettinger's views, and replies by some of his critics, see Anthony Oettinger and Sema Marks, "Educational Technology: New Myths and Old Realities," Harvard Educational Review, vol. 38, no. 4, Fall 1968, pp. 697-755 (also Reprint Number 6, Harvard University Program on Science and Technology).

[2] Harry F. Silberman, Systems Development Corporation, Santa Monica, California, in unpublished paper, "Applications of Computers in Education," presented at the American Management Association Conference on Education and Training, New York, August 8, 1967.

aided instruction is estimated at less than 6 per cent of the total 1970 market for tape recorders, language labs, movie projectors, overhead projectors, standard TV and closed-circuit TV receivers — totalling $113.5 million in 1970.[1]

But some disagree with these views. While a majority of those attending an "instructional systems seminar" in August 1967 insisted that "CAI is just for research now," a smaller group viewed "CAI as an instrument for teaching now - to supplement, or complement, if not to replace, conventional classroom instruction."[2]

These views are best evaluated after a brief review of current experience with computer-aided instruction and other computer applications in education. The remainder of this chapter will consider the needs to be met, first steps and principal recent applications in the administration of educational services (in primary, secondary, and higher education), estimates of costs, implications of CAI for people and organizations, and resistances to be encountered. A summary of technical and non-technical problems in computer applications in education will conclude the chapter.

The needs

Faced with a shortage of teachers as enrollments expand, educational institutions may find that computers will assist instruction and administration in meeting the following needs:

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[1] Dwight C. Macauley, The Market Outlook for Instructional Technology, Arthur D. Little, Inc., Cambridge, Massachusetts, October 1966, p. 16 and data in Table 7, p. 14.

[2] Robert M. Gordon, summarizing results of seminar sponsored by the Science Research Associates, a subsidiary of IBM, in Chicago, August 2-4, 1967, Datamation, vol. 13, no. 9, September 1967, p. 70.

1. To relieve teachers of repetitive, structured, drill-type work, as in elementary and some secondary mathematics, reading, spelling, and grading routine exercises. These are the tasks that are often unattractive to teachers.

2. To provide teachers with continuous evaluation of their students' work, in a system which stores records of student performance on assignments, drills, etc., and provides the teacher with a periodic cumulative printout.

3. To permit slower students to set their own pace in CAI, thus avoiding peer group and teacher pressure. One report indicated that "poorer students reacted best to CAI. They felt they were receiving more attention and were less conscious of peer pressure."[1]

4. To permit faster or advanced students to use the computer for more difficult work, or "as a facile and literalistic slave which they can learn from by ordering him around" (to use a phrase from the M.I.T. Colloquium on Computers and Education). The emphasis here would be on computer-aided learning rather than on instruction as such, and would involve learning to write programs, and to interact with the computer in an on-line real-time sense.[2]

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[1] Mrs. Sylvia Charp, Director of Instructional Systems, Philadelphia School District, in discussion at American Management Association Conference on Education and Training, New York, August 9, 1967.

[2] These points were stressed during the weekly Symposium on Computers and Education sponsored at M.I.T. by the staff of the Education Research Center. The emphasis on computer-aided learning was also made at the colloquium by Professor Ralph W. Gerard of the University of California (Irvine), May 1, 1968.

5. To improve instruction in basic structured subjects, which are not being taught effectively in many schools and colleges, because of large enrollments and teacher shortages. Such subjects might include some parts of geometry, biology, basic psychology, foreign languages, library science, and others.

6. To assist educational administrators in the complex and time-consuming tasks of classroom and course scheduling, preparation of student programs, keeping of student records, preparing payrolls, provisional budgets, and other financial records. In a more sophisticated sense, computer-aided systems analysis could aid administrators in allocating more effectively the total resources (financial, physical, and human) available for a given period.

Some Initial Steps

Initial developments in computer-aided instruction have been influenced by the earlier experience with non-computerized "programmed instruction," including the "teaching machines" which were introduced between 1955 and 1960. The initial interest in the latter apparently soured. As one study observed, "What the teaching machine fiasco really proved is that no machine can be designed to impart knowledge until the builder of the machine understands the learning and teaching process."[1] Some programmed instruction utilized frames on teaching machines; some involved programmed texts. A review of this experience in 1962 for the Fund for the Advancement of Education concluded:

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[1] Dwight C. Macauley, op. cit., p. 6.

"Although the research gives us little reason to be satisfied with the theories and the standards of today's programming, and every reason to believe that it will be possible some day to make programs vastly more effective than today's programs, nevertheless programmed instruction shows signs of hardening, partly under commercial pressure, into a fixed and mechanical technology, with theories and procedures taken for granted."[1]

While the chronological sequence of early computer-aided instruction programs is difficult to determine, there were at least two such efforts in 1964. A computer-based "laboratory for Learning and Teaching" was established at Stanford University in 1964, under the direction of Professor Patrick Suppes. It has subsequently received considerable publicity for the variety of CAI programs it has developed and tested at the primary, secondary and even college level. (These will be noted below.)

Another pioneer effort was apparently the "Talking Typewriter," growing out of an early development by Professor O. K. Moore of Ohio State University. It has been used in teaching reading and writing, especially for disadvantaged children in the Brownsville Section of Brooklyn, and with kindergarten and beginning primary grades in various cities.[2]

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1 Wilbur Schramm, Programmed Instruction—Today and Tomorrow, New York: The Fund for the Advancement of Education, 1962, p. ii. Subsequently, Schramm edited Four Case Studies of Programmed Instruction for the Fund, published in 1964, and concluded, "On the basis of these studies, it appears that truly individualized instruction with programmed material can be achieved only by a really major change in the contact of teaching and learning," p.15.

2 Information supplied by the Responsive Environments Corporation, which markets the McGraw-Edison computerized talking typewriter.

Principal Recent Applications

A. Primary Education

1. The Stanford group, now known as the Institute for Mathematical Studies in the Social Sciences, has developed computer-based mathematics instruction for both (a) individualized drill and practice, for grades 1 through 6, in cities in California, Mississippi, Kentucky and Iowa, and (b) tutorial systems in which the student is given basic concepts and skills, at his own pace. In the latter, the computer program has the main responsibility. In contrast, the drill and practice system "is designed to supplement what the teacher does in the classroom. So we're restricted to what the teacher does, not what we think she should do. No curriculum design is involved at this stage."[1]

The Stanford group is also apparently working toward "dialogue systems," but these are some distance away, "because a number of technical problems remain unsolved. One problem is the difficulty of devising a computer that can 'understand' oral communication, especially of young children."[2]

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[1] Patrick Suppes, "The Teacher and Computer-Assisted Instruction," NEA Journal, February 1967, pp. 15-17. In the fall of 1968, the drill and practice program was used by 2,000 children, and the tutorial systems were in use by first-graders in one California school and by fourth-graders in another. Suppes has characterized the former as "a strict operational implementation of individualized drill-and-practice in elementary mathematics." During 1968-69 the number of students involved is over 7,000. Patrick Suppes, reply to Oettinger and Marks, Harvard Educational Review, vol. 38, no. 4, Fall 1968, p. 37

[2] Ibid., p. 16.

2. A computerized program for teaching elementary mathematics (really addition and subtraction) and spelling is being tried in 16 public schools in New York City.[1]

3. Bolt, Beranek and Newman, a Cambridge, Massachusetts, technical consulting firm has developed a new computer language (LOGO) to "stamp out fuzzy thinking and teach third grade mathematics in some suburban schools."[2]

B. Secondary Education

1. Several efforts have been made in high schools to teach computer programming to students. One for junior high school students in Santa Monica, California, was developed, but apparently the first course on computer mathematics in any high school was started in a New York City high school early in 1964.[3]

2. An experimental CAI program for elementary mathematics in Massachusetts also involves encouraging students to "teach the computer by writing their own programs." This has been developed by the Massachusetts State Department of Education for grades 9 to 11 in several suburban schools. In a normal classroom, "a student would not have a chance to

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[1] New York Times, March 19, 1968. A tie with the Stanford computer was used until RCA installed one in New York City.

[2] As reported by two staff members at the M.I.T. Symposium, Spring 1968.

[3] As reported in the New York Times, April 16, 1964. For the Santa Monica experience, see Silberman, op. cit., p. 3.

teach someone else. The project has turned into one to determine how to get kids and computers together," rather than using the computer for drill and practice only.[1]

3. The School of Education at the University of Illinois has been developing a computer-based system known as "Plato" over a number of years, using it first for the instruction of maternity nurses and later for some secondary school subjects, particularly mathematics. The system will ultimately involve some 4,000 student terminals with a key-set and a plasma-display device which is cheaper than the usual cathode ray tube. The terminals and displays are tied to a central computer, but the displays also permit projection of locally-stored information.[2]

C. Higher Education

The expanding use of computers in colleges and universities means that more and more students are learning to use computers as part of their formal courses, as well as in research projects. In 1967, an official of the National Science Foundation reported that approximately two-thirds of all college students were attending colleges and universities with computer facilities of some sort, and this proportion is undoubtedly rising each year. Few of tomorrow's college graduates will be computer ignoramuses, as many of yesterday's still are.

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[1] As reported by Dr. Jesse O. Richardson, Massachusetts State Department of Education, Colloquium Series on Computers and Education, sponsored by the Education Research Center of M.I.T., February 28, 1968.

[2] Donald L. Bitzer at M.I.T. Colloquium Series, February 14, 1968; and also as reported by Wayne H. Holtzman, Items, p. 44. Criticisms of this system are reported in the latter reference.

1. Dartmouth College students learn a simplified English-like language called BASIC, developed by Professor John Kemeny, Chairman of the Mathematics Department. This language is implemented on a large GE time-sharing computer system. Professor Kemeny claims that about 80 per cent of the students are proficient BASIC programmers, with the business school students being the largest users. The Dartmouth program also involves participation by 10 other colleges and 20 secondary schools, mostly in New Hampshire, through leased wires to the central computer. According to Kemeny, the greatest learning experience for the student is in teaching the computer how to do something, because "if you really want to learn something, teach it to someone else."[1]

2. Civil Engineering students at M.I.T. use a small computer in the Department for solving design problems. Other M.I.T. students have used separate computers (as in the Sloan Building for Economics and Management), but the move is toward terminals tied in to the central M.I.T. Computation Center or to Project MAC (Machine-Aided Cognition or Multiple Access Computer), which was the prototype of all time-sharing systems.

At this writing, no complete college-level course is programmed for computer-assisted instructed, although research is underway in several. Among these is the pioneering effort in the Sloan School of Management to develop an "associative learning instructional system" as a part of the first-year graduate course in management information and control systems (management accounting).[2] While still an experimental prototype, the

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[1] At M.I.T. Colloquium Series on Education and Computers, April 17, 1968.

[2] Zenon S. Zannetos and Michael Scott Morton, Efforts Toward an Associative Learning Instructional System, Sloan School of Management, M.I.T., Working Paper 355-68, August 1968. This work is continuing under a three-year grant from the Ford Foundation.

system is intended to offer the student an associative memory to related fields as it provides him with interactive flexible search procedures and has the ability to learn and adapt on the basis of his progress.

3. The Stanford University Institute for Mathematical Studies in the Social Sciences began experimenting late in 1957 with a completely computerized first-year Russian language course, programmed by a professor of Slavic Languages at Stanford. This purports to eliminate the teacher completely; language laboratory and homework are in the automated program. Language instruction is clearly more structured than many other college-level subjects. Professor Suppes, Director of the Institute, admits that more complex programming would be necessary for the "discussion-type" subjects, such as history, literature, and many of the social sciences. He sees CAI in these subjects as "some distance away."[1]

4. A "Learner-Controlled Statistics Course" has been developed in California to permit the student to chart his own path through the course.[2] Using "maps" of the course in different degrees of detail, the student selects (with a light pen on a cathod ray tube) those parts in which he feels he needs most help. The computer also audits his progress. This type of programming requires a much greater computer storage capacity than does a completely structured course, illustrating again the greater complexity involved. At the same time, it has a greater appeal to those students who want <u>less structure</u>, preferring to search out their own material at their own pace, as in individualized study in a library.

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[1] Oral comments at M.I.T. Colloquium, March 6, 1968.

[2] Ralph E. Grubb, paper presented to American Management Association Conference, New York, August 1967. The paper was earlier reproduced by IBM, Los Gatos, California, April 5, 1967.

Administration of Educational Services

Among these are computer-grading of student examinations and papers; computer-programmed student counselling and vocational guidance; class scheduling; management information systems to monitor progress toward educational objectives; and computer systems for optimum allocation of educational resources, as well as for preparing payrolls, accounting, etc.

A few examples illustrate computer applications in these areas:

1. Computer-graded examinations are used as a part of "computer-monitored" instruction at Long Island University in New York. The University of Connecticut has experimented with a computer-program for grading high school English compositions, and the reported results were found to be indistinguishable from grades assigned to the same papers by a panel of four high school and four college English teachers. It is claimed that the program analyzes not only spelling, grammar and syntax, but even makes assessment for "sense."[1]

2. Student program counselling, to assist the student in preparing his program for the following year, through a series of questions written into the computer program, was developed in 1968. According to the report, students preferred the non-human counselor, which was more responsive to student preferences, than the human counselor, who tried to suggest what the student should or should not take.[2] Of course, the question of whether student preferences should always prevail may not have been considered.

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[1] As reported by Dr. Louis Bright of the U.S. Office of Education at M.I.T. Colloquium, April 10, 1968. For a fuller account of the Connecticut experience, see Ellis B. Page (University of Connecticut, "The Use of the Computer in Analyzing Student Essays," International Review of Education, vol. XIV, no. 2, 1968, pp. 210-225.

[2] As reported by Harry F. Silberman, Systems Development Corporation, Santa Monica, California, in talk at American Management Association Conference, New York, August 9, 1968.

3. A computer-based information system for vocational decisions is being developed by the Graduate School of Education at Harvard University, in collaboration with the New England Education Daday System (NEEDS) and the Newton, Massachusetts public school system. "The program is to be so designed that a student can relate knowledge about himself to data about education, training, and work, and thereby create a body of information in which he can base his career decision. The entire program links person, computer, and teacher as counsellor in such a way that the student can conduct a dialogue with the computer, while the counsellor assists in interpreting and evaluating the results of the dialogue."[1] A prototype system is to be in operation by July 1, 1969.

4. The School Scheduling System has been developed at Stanford University for use by secondary schools. This computerized service provides scheduling services for a substantial number of schools throughout the United States.[2] Purdue University has developed a program which uses as its criteria the efficient useof classroom space, students' course preferences, and professors' preferences. Students got their own preferences 76 per cent of the time, according to one report, as compared to 22 per cent before. These student preferences were also often a surprise to some professors, apparently.[3]

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[1] Information Systems for Vocational Decisions, Annual Report (Harvard Graduate School of Education), 1966-67, pp. 1-2. The project is financed by a grant from the U. S. Office of Education.

[2] For details, see Robert N. Bush and Donald H. Delay (both of Stanford), "Making the School Schedule by Computer: Opening New Educational Alternatives," International Education Review, vol. XIV, no. 2, 1968, pp. 169-181.

[3] Time, December 8, 1967, p. 110.

5. A more sophisticated effort to provide course and program evaluation measures is being developed at the M.I.T. Sloan School of Management, as a part of the Management of Education research project as well as for internal use in the School. These measures are based on objectives set by the faculty responsible for the courses offered; student demographics, knowledge, skills, attitudes, and expectations; and student and faculty perception of change attributable to specific courses in the academic program. The objective is to develop a prototype university "management information system" to evaluate progress toward educational objectives for use by other programs and educational institutions.[1]

A somewhat similar program at the primary and secondary school level is being developed by the Center for Research and Evaluation in Applications of Technology in Education (CREATE), which operates under the auspices of the American Institutes for Research in the Behavioral Sciences, Palo, Alto, California.[2] According to the director of this project, Dr. John C. Flanagan:

> "The development of a system of education of this type requires the formulation of detailed performance-related educational objectives; the development of measurement and assessment devices for monitoring progress in attaining each objective; the development of guidance procedures for planning each individual's educational program in terms of detailed performance-related educational objectives; the assembly and cataloging of the modular teaching-learning units appropriate for various types of students, and the preparation of computer programs and procedures which will enable the teacher and student to use the computer effectively."[3]

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[1]This research is under the direction of Professor Arnold E. Amstutz of the Sloan School, and is now supported by grants from the Carnegie Commission on Higher Education and the Ford Foundation, covering a three-year period beginning Fall 1969.

[2]John C. Flanagan, "Functional Education for the Seventies," reprinted from the Phi Delta Kannan, September 1967, by the American Institutes for Research, Palo Alton, California. The project has partial funding and technical assistance from the Westinghouse Learning Corporation.

[3]<u>Ibid</u>., p. 29

A functioning model of the system was tested in 14 school districts during 1967, and it was expected that students in grades 1 through 12 would be using the new system by September 1970.

6. Computer systems for optimum allocation of university resources are being developed at California, Toronto, Michigan State, and M.I.T.[1] among others. Objectives vary, but initially they seek to optimize the use of classroom and laboratory space in scheduling students and teachers in each course, given financial resources and constraints. But analytical models might also be used for (a) strategic planning problems, assuming different parameters over time, as well as for (b) management control problems in carrying out defined objectives in shorter periods. These systmes are obviously more advanced (and experimental) than the present use of computers in such things as preparing payrolls, financial accounting and control, and student class scheduling and class rolls.

Estimates of Costs

It may be futile to discuss costs of computer-aided instruction, or osts of computer-based educational services. Most of the literature and many of the oral discussions have been concerned with present CAI costs (which are bound to be high in experimental programs) with estimates of future costs per student hour under favorable assumptions. For example, if terminal costs and communication costs come down in the aggregate, and if large-scale applications of CAI are possible over the next 10, 15, or 20 years, then costs per student hour will be drastically lower than at present. More specific examples will illustrate this general point.

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[1] These are financed by grants from the Ford Foundation.

1. The high cost of present cathode ray tube terminals in time-sharing computer systems is one of the reasons why Professor Donald Bitzer of the School of Education at the University of Illinois is attempting to develop the cheaper plasma-display device as a substitute terminal (mentioned earlier). He estimates that the direct operating costs of instruction in such a system would be 25 cents per student hour, but critics have called these estimates unrealistic and suggest $2.00 per student hour is more likely.[1] And these figures do not include initial capital costs (hardware and software) which would have to be computed full cost per student hour over a specified period.

2. Patrick Suppes of Stanford has estimated that "with current technology and without involving large numbers of students, individualized work in arithmetic and in spelling could be brought to school districts at a cost of $0 to $50 per student per year (roughly 30 cents per student hour) if it were installed in reasonable numbers. ....On the other hand, tutorial instruction for special, remedial or vocational education, or for handicapped children, is very, very much more expensive....$3 to $4 an hour."[2]

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[1] Wayne H. Holtzman, Items, p. 44. When Bitzer was questioned at the M.I.T. Colloquium Series about costs for the 27,000 school districts in the United States, he replied, "This will be a $50 to $100 billion a year business before we're through."

[2] Patrick Suppes, The Computer and Excellence," Saturday Review, January 14, 1967, p. 48. Suppes used a figure of $2,000 per terminal, which he believes mass production would reduce to $1,000 per terminal, "including the cost of curriculum development and preparation." With approximately one million elementary school classrooms in the country, it would cost about $1 billion to install a minimum of one terminal per classroom over a ten-year period. Ibid., p. 50. For alternative calculations of costs for drill-and-practice as compared with tutored systems for 100,000 students, see Clyde N. Carter and Maurice J. Walker, "Analyses," in Costs of Installing and Operating Instructional Television and Computer-Assisted Instruction, Booz, Allen and Hamilton, New York, 1968.

3. Even if average per student hour terminal costs were as low as $1.40 an hour, this "looms large when one realizes that a typical school system like Watertown (Mass.) spends only $4.00 per year on books for each student. The bulk of its school budget (slightly over 80 per cent) goes for salaries."[1]

4. In addition to heavy initial capital costs, there will be substantial costs for the development, maintenance, and upkeep of high quality programs (software) for CAI. "About 100 hours of author time is involved in the development of one hour of student console time for instructional applications. There doesn't seem to be any easy solution for this problem."[2] The more difficult and less-structured the subject matter, the greater these costs are likely to be. For example, a learner-controlled statistics course requires more programming effort than a structured course. To keep students interested at the college and university level, "The faculty will have to devote many hours of intensive effort creating acceptable instructional sequences; this is neither a part-time nor a trivial activity."[3]

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[1] Oettinger and Marks, op. cit., p. 19.

[2] Silberman, op. cit., p. 13.

[3] Robert M. Gordon, writing in "The Forum," Datamation, vol. 13, no. 2, February 1967. He chided individual experiments in CAI with "neglecting the critical aspects of the systematic use of the computer outside their laboratories: the world in which each of 20,000 university students spends 15 hours per week at a 'teaching terminal' is very different from the world in which, occasionally, students make use of perhaps a dozen or fewer terminals." p. 124.

5. If costs per student hour are to come down with widespread applications of CAI, the present lack of uniform coding standards and lack of effective language translation programs will have to be faced. One CAI expert has concluded: "Greater allocation of resources today to developing metalanguages that are completely machine-independent may be a more efficient way of spending educational development monies than to support a large number of small scale CAI projects which are not transferable to other systems."[1]

While actual cost estimates vary widely, the Subcommittee on Economic Progress of the Joint Economic Committee of the Congress concluded from the testimony before it, that "to receive widespread application the amortized cost of computerized instructional equipment should not exceed 25 cents per student hour in elementary schools and 50 cents per student hour for special education." In terms of initial capital costs, "somewhere between $2,000 and $4,000 per student console" (terminal) is the feasible price range "which might possibly be reached in a few years." And, "after specific curriculum objectives are established, the proper programming of such equipment would cost approximately $4,00 to provide material for one hour for an average student."[2] This was written in 1966, but at the M.I.T. Spring 1968 Colloquium Series on Education and Computers, none of the speakers claimed that these objectives had been reached. As in other computer applications, the time-span of achievement is always slower than the earlier predictions. But if other obstacles to widespread use of CAI can be overcome, the costs will certainly come down enough to make CAI economically feasible.

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[1] Silberman, op, cit., p. 13.

[2] Report, op. cit., p. 8.

Some Long-Run Implications of Computer-Aided Instruction

The initial experiments and applications of CAI, reviewed above, suggest the following implications on the way teaching will be done, the student's relation to the computer, and probable changes in the organization of schools and colleges.

1. Teachers will be relieved of the repetitive, structured drill-type of teaching, and possibly of grading of routine papers and examinations. Presumably, when teachers are relieved of these chores, they will have more time for the creative aspects of teaching: working with individual students on difficult subject matter not programmed for CAI, discussing possible implications of points raised by students, bringing new material to the class and relating it to other areas of knowledge. CAI will probably require more imaginative teachers than before; no longer will drill-work suffice to fill the class hours, particularly at the elementary and secondary school level. This may discourage some present teachers, but it may attract others because of the new possibilities.

2. In this type of CAI application, the student will have a private "tutor" in the machine, and can set his own pace. At secondary and higher education levels, student interaction with the computer will be more frequent, for statistical analysis, solving problems, testing models, simulating experience, and even exploring interrelationships between areas of knowledge in an interactive sense, providing an imaginative enough program is available in the time-sharing computer.

But visionary predictions which suggest that "with this new technology we may be able to give each kid the personal services of a tutor as well

informed and as responsive as Aristotle,"[1] seem a long way off. This would require voice-to-voice interaction between student and computer, with the computer "conducting a free and clever dialogue with the student," and possessing true "artificial intelligence." Anthony Oettinger, who has been concerned with artificial intelligence studies at Harvard, warns of the dange of "technological overkill." In education, he is more concerned with natural intelligence amplified by the machine, rather than with the possibilities of artificial intelligence as a substitute for the classroom teacher. The blackboard is still useful.[2]

3. The persistent teacher shortage may be relieved somewhat by CAI,[3] but a more important effect is the changing of the teacher's role. In addition to having more freedom to innovate in other ways, the teacher will become part of a team of specialists, some of whom will be "specialists in communications, psychology, audio-visual instruction, curriculum [design], and other subjects, working together to provide resources and instructional guides for teachers as well as students."[4]

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[1] Patrick Suppes (Stanford) as quoted in "The Computer as Tutor," Life, January 27, 1967. Subsequently, at the Spring 1968 M.I.T. Colloquium Series, Suppes admitted the difficulties, however, of even simpler student-computer audio communication: "This is a difficult problem. How does a computer program analyze what the student has done and then say something to help him?"

[2] Quoted in Datamation, vol. 13, no. 2, February 1967, p. 70.

[3] There is practically no evidence or even discussion, however, that CAI will enable teachers to handle larger classes, although it might seem likely. Computer assisted educational services such as examination or essay grading, would also seem to help teachers have more students.

[4] Macauley, op. cit., p. 18. For a similar view, see Norman D. Kurland, "The Impact of Technology on Education," Educational Technology, vol. VIII, no. 20, October 30, 1968, p. 14. Kurland believes that "the obvious increased productivity and level of professional competence of a teacher who directs a learning system and participates in the creation of effective learning materials will justify a reward more nearly commensurate with the training and ability required for the task."

4. There is no evidence, and there have been no predictions, that any teachers will be displaced by CAI. As poorly prepared as some teachers may be their skills extend beyond conducting repetitive drill-type work, which the computer will certainly take over. Even the first-year college Russian Language program developed at Stanford, which purports to eliminate the need for teachers completely, would not displace a single teacher of Russian Language and Literature. He would be freed of beginning courses at best, with more time for advanced teaching. And it would also seem likely that beginning students may still have unstructured questions they would like to raise with a human teacher.

On the other hand, it is also probable that if CAI can handle beginning courses in mathematics, languages, and science in secondary and higher education, fewer new teachers may have to be hired, assuming the same student enrollments. But enrollments are expanding so that the slowness with which the new technology will spread in the next 10 or 20 years, makes this a very long term possibility.

5. There will be changes in the organization of teaching and educational institutions. The prospect of the teacher as a member of a team of educational specialists has already been mentioned in paragraph 3 above. School and college libraries as adjuncts of teaching (as well as research) may change with computerized information retrieval systems, but the computerized library of the future (as we shall consider in the next chapter), will still be supplemented with actual books "on reserve" for courses, for student browsing, and for ready reference. The availability of national (or even international) programs and CAI systems for drill-type work and for tutorial tasks will relieve the local school or college of having to

prepare these for itself. For example, the programs developed at Stanford University are being used in a number of school systems; and this type of reapplication could spread. All of this assumes that eventually there will be a truly national system, with uniform programming languages, which is not now the case. Possibly regional educational utilities, similar to the time-sharing system at Dartmouth, are more likely.

In any case, the role for the major university may be to innovate in developing new applications of CAI for use by other colleges, including community colleges and junior colleges which generally lack staff capability to develop their own programs. Sometime in the future, it is possible that some universities and their faculties may concentrate exclusively on computerized educational program development, leaving application of these programs to the teaching staffs of institutions of higher education. Another possibility is that the so-called "learning corporations" (textbook firms allied with computer systems firms) will become the innovators, moving the major educational development function out of the universities and into the profit-making corporate world.[1] While some educational

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[1] Some of the initial bloom seems to have gone off the "learning corporation" rose, however. A recent survey of the experience of such firms as General Learning (GE and Time-Life), Westinghouse Learning, Raytheon Education, Xerox, CBS-Holt, and others, begins: "In virtually every case the newcomers announced their arrival with much fanfare, high hope and brave talk. In most cases, they have subsequently encountered—or created—serious problems. So far, in fact, their results have been disappointing." Ralph Kaplan, "Learning the Hard Way: In the Knowledge Industry, Most Corporate Freshmen Have Flunked," Barrons, vol. XLVII, November 15, 1968. Kaplan concludes, however, "it may be that these firms 'have the inside track on tomorrow's education-information markets'," in contrast to traditional textbook companies. The survey by Arthur D. Little, Inc. discussed five "integrated systems firms" which "do not expect to have a substantial impact on the marketplace until the mid-1970's." Macauley, op. cit., p.23.

programs have already been developed by computer manufacturers or learning corporations separately, it is likely that they will also continue to work with university-based efforts.

6. More centralization of educational instruction planning and educational administration will occur in school districts with central computer systems. More or less standardized materials will be prepared for student use at classroom terminals in each school in the district, with the results being evaluated by machine and summaries of each student's progress prepared for the teacher. One prediction of this classroom of the future continues:

> "When it has digested the results of each class's performance, the computer composes the next lesson....Any computer-assisted instruction worth its cost must be able to read handwriting, and interpret lengthy statements in natural language....It will require sophisticated compilers to process and evaluate such answers, and this requirement represents the major technological obstacle standing between the experiments of today and effective computer systems for instruction in the schools of tomorrow."[1]

Against this trend toward centralization is the possibility that some schools may go in the direction of small, stand-alone computers rather than being a part of a massive time-sharing system. Less sophisticated hardware, software, and personnel are required; and if one computer "goes down" the entire system is not down. On the other hand, the schools could draw programs from a central program library, developed and maintained by, say, the State Board of Education.

7. Further in the future is the educational or instructional utility system which not only provides programmed instruction through classroom or dormitory terminals in schools and colleges, but also for use through

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[1] James Rogers and Donald Cook, "The Computer and the School of Tomorrow," Datamation, vol. 12, no. 5, May 1966, pp. 41-44.

terminals in the home, so that in-school as well as adult education can proceed at the individual's own pace and level of interest. By making such programs available outside of school classrooms, CAI will be more widely available and may even change the function and size of future schools. If classroom space does not need to expand to take care of all "students," teachers may function less as instructors and more as "resource" people, available for consultations by appointment with individual students as they encounter difficulties not programmed in CAI or as they yearn for interaction with a human teacher sometimes. Under such a system, teachers would need to be competent not only in the subjects covered in CAI programs, but also in related and broader areas of knowledge. They would obviously be expected to help, at the students' initiative, a much larger number of students. The personal teacher-student relationship which develops in today's classrooms would give way to a more impersonal client-specialist type of relationship, perhaps not unlike that between patients and doctors in a large medical clinic. This type of development, if it should occur, would obviously modify the conclusion in paragraph 4 above.

8. Centralization of CAI has dangers as well as opportunities. There is the possibility that "a system based on remote information storage might make control over subject matter far easier than it is in our present society. One need only picture the use a Hitler or a Stalin could have made of a national educational information pool to understand the seriousness of this problem....teaching all children the same history might be all too easy and gaining control over the mind of a national all too possible unless this question is most carefully studied and intellectual

freedom most jealously guarded."[1] Perhaps fortunately, the absence of federal control over education in the United States makes this less likely than in countries with highly centralized educational systems, where curriculum and standards are prescribed on a nation-wide basis.

Resistances to be Met in Introducing CAI

Some of the implications discussed above suggest resistances which will have to be met as CAI is introduced beyond the present experimental level. These may be summarized briefly.

1. A national or a regional CAI system will have to be acceptable to the boards and administrators of all or some of the 26,000 (or more) separate school districts in the United States. Costs of such systems will compete with funds available (or raised by more taxes) for new buildings. teachers' salaries, etc. If a school or a school district could use a smaller computer of its own, with standard programs, as suggested earlier, differential progress may be made.

2. Teachers and their organizations may also resist CAI if it seems to be a threat to traditional teaching methods in which they have been trained, or if it requires considerable retraining on their part. "Teachers must be trained to use new equipment--and training takes time. Moreover, if teachers feel their prerogatives are being threatened, their resistance must be overcome."[2]

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[1] Anthony G. Oettinger, "A Vision of Technology and Education," Harvard University, Program on Technology and Society, Reprint Number 1, 1967, pp. 8-9.

[2] Macauley, op. cit., p. 5. The attempt to assist teachers with specialists from outside who develop CAI programs and curricular "is likely to meet with some resistance, simply because it might be interpreted as incursion into what has heretofore been strictly the educator's pr vince—the determination of course content, materials, and teaching methods." p. 18.

3. The attempt of some learning corporations to provide a "total educational system" is a threat to present school systems. This is reminiscent of the talk about "total information and control systems" in management, which stirred management apprehensions in the mid-1960's (but which still seems a decade away). Even more serious is the criticism that the learning corporations "have only the vaguest notion of what an educational system is supposed to do. ....There nees to be far more progress in finding out just how children learn.[1]

4. To the extent that the CAI specialists - the systems designers - make the same mistakes that were made in earlier computer introductions in management operations, there will be the normal resistance to change by those "being changed." This type of resistance can certainly be reduced, as it has been in business situations, by encouraging the participation of both teachers and school administrators in the development of CAI applications to their own subjects and schools. "Marathon sessions between school personnel and systems designers provide an opportunity for each group to confront one another, not only with their biases but also with their particular resources for systems design."[2] The dangers of "professionalism without humanity" are as great here as in any other area of computer systems application; perhaps even greater because students as well as teachers are the ones affected by the new technology.

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[1] Anthony Oettinger, quoted from M.I.T. Colloquium on Computers and Education, in Technology Review, April 1968, p. 50.

[2] Silberman, op.cit., p. 14. A university School of Education Dean has put the same point in these words: "The demands of research and development lead the computer innovators to neglect the need for relating their work to existing practices in the mainstream of American education, particularly recent reform efforts, and to ignore the implications of their work for personnel organization and training, all potent factors in future acceptance patterns." Judson T. Shaplin, Don D. Bushnell and Dwight W. Allen (editors), The Computers in American Education, New York: John Wiley & Sons, Inc., 1967, p. 36ff.

5. A final difficulty may be the shortage of competent systems designers and programmers for CAI. Will enough of them be available to make a real impact - with the cooperation of teachers and school administrators - in this difficult area, when there are more opportunities for immediate applications in business management, for example? There is also the uncertainty about how children learn, and whether any CAI can be developed which will advance the learning process significantly. Anthony Oettinger, who is quoted at the beginning of this chapter as being "depressive" about the short run potential of CAI but more optimistic about the longer run, has put it this way: "The information available at the terminals will be prepared by people, and it is questionable whether the available people will have enough ideas and enough command of the technology to do a job good enough to interest the students."[1]

Summary

The previous discussion may be summarized with the statement that computer-aided instruction is now plagued with two major types of problems: (a) technical, including costs of hardware that are still too high, and (b) non-technical problems that are even more difficult. These are elaborated in the following points:

1. Present terminal costs are too high, with the result that alternative hardware is being developed. Transmission costs also add to student hour costs. But the largest element in costs is the development of suitable programs for individualized instruction.

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[1] Anthony G. Oettinger, "A Visitation of Technology and Education," p. 7.

2. Computer hardware and software are not yet available for dialogue-type interaction between the student (speaking in natural language), with the computer responding by asking questions and being helpful. Present experimental applications have been confined to the computer as a calculator, as an aid to logical thinking (through writing programs) and routine drill-type applications, as in elementary mathematics. The computer as tutor is still limited.

3. Present experimental applications are largely funded <u>outside</u> of school and college budgets. It is a big jump from a few studies financed by the U.S. Office of Education, or by foundations, to large-scale financing in thousands of school districts, either out of their budgets or with federal support.

4. A national system is handicapped by the lack of uniform program languages and coding, by the resistance of the education establishment, and by lack of enough able, imaginative systems designers and programmers who must work with teachers and educators, and not impose systems on them.

II

Library Systems and Sub-Systems

The case for applying electronic information processing technology to the storage and retrieval of published works was first made while the computer was still little more than an experimental device. Dr. Vannevar Bush saw this need almost 25 years ago:

> "The difficulty seems to be, not so much that we publish unduly in view of the extent and variety of present-day interests, but rather thatpublication has been extended far beyond our present ability to make real use of the record. The summation of human experience is being expanded at a prodigious rate, and the means we use for threading through the consequent maze to the momentarily important item is the same as was used in the days of the square-rigged ships."[1]

Within a little more than a decade, the Ford Foundation had established a Council on Library Rescources in 1956 to explore the benefits of modern technology, including the storage and retrieval of information. A study of "the library of the future" got under way in November 1961, directed by Dr. J.C.R. Licklider, who probably wrote what was the first book on the subject.[2] Subsequently, many other studies and publications, both specialized and general, have been undertaken. However, the fully-computerized library system is still "in the future."

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1 Vannevar Bush, "As We May Think," Atlantic Monthly, vol. 176, July 1945, pp. 101-108.

2 J.C.R. Licklider, Libraries of the Future, The M.I.T. Press, Cambridge, Massachusetts, 1965. The Bush quotation was cited in the Foreward to this book.

The Need

The information explosion mentioned in 1945 by Dr. Bush has accelerated. Licklider has been quoted as saying that the output of readable material doubles every 10 years.[1] Another general statement often cited is that "90 per cent of all the scientists who ever lived are now at work," but no one can read all that is written. One report stated that during 1964, 20,543 new books and 7,707 editions of older books were published in the United States - a total twice the 1960 rate. In addition, there were also 22,262 periodicals and 80,000 technical reports published in 1964 in this country.[2] These figures do not include unpublished but circulated papers and monographs.

National as well as college and university libraries are exploding. In 1965, the Library of Congress had 40 million 3 x 5 cards in its catalog files; the New York Public Library had 2.4 million - many quite soiled and dog-eared.[3] In his paper on "A Library for 2000 A.D.," Professor John G. Kemeny of Dartmouth College said that Harvard University will have a library of more than ten million volumes by that date, and that Dartmouth will have two million by then. He added, "it is clear that

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[1] New York Times, January 9, 1967.

[2] Time, September 3, 1965, p. 52. These data are almost "too precise" to be taken literally. Another estimate, by an Atomic Energy Commission official, is that one million scientific articles are being printed annually in 35,000 journals. New York Times, June 1, 1967.

[3] New York Times, April 17, 1966.

the cost of building, purchasing volumes, cataloging, and servicing these monstrous libraries will ruin our richest universities."[1]

Not only is the volume of scholarly output growing, but as fields converge, it is often necessary for a scholar to have access to recent research in much more than his own specialized field. Furthermore, since scholarship knows no national boundaries, access to published works in other countries is essential. This will require a world-wide information retrieval system.

Initial Efforts

These needs led to efforts to apply computerized information retrieval systems to library sub-systems. Among the first efforts were the following:

1. About 1960, Dr. Meyer M. Kessler (then at M.I.T.'s Lincoln Laboratory) began experiments with recording on computer tape certain data for each article in the Physical Review for the preceding ten years. Subsequently, he reported that some 60,000 bibliographic citations from 17 physics journals could be retrieved via teletype connected directly to the computer.[2]

2. A Medical Literature Analysis and Retrieval System (MEDLARS) has been in operation at the National Library of Medicine in Bethesda, Maryland, since January 1964. Three years later approximately 486,000

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[1] John G. Kemeny, "A Library for 2000 A.D.," pp. 135-136 in Ch. 4 in Martin Greenberger (editor), Computers and the World of the Future, The M.I.T. Press, Cambridge, Massachusetts, 1962.

[2] The early experiments were briefly mentioned by Kessler in Kemeny, op.cit., p. 169, discussion. The later report was in "Librarians Told of Computer Aids," New York Times, May 31, 1967. Dr. Kessler is now Associate Director of the M.I.T. Libraries.

citations from 2,400 bio-medical journals were stored on magnetic tape, available for search requests from scientific investigators and members of the health professions. Some delays were reported by users.[1]

3. Computer tapes of all new English-language monographs received and catalogued by the Library of Congress have been distributed to 16 research libraries in the United States. This experimental project was begun in 1966 as Project MARC (Machine Readible Catalogue), and eventually the entire catalogue might be put on computer tapes.[2]

4. Several information retrieval systems for scientific and engineering information have been developed by firms for their own internal use. IBM's Technical Information Retrieval Center provides access to 125,000 documents, plus 10,000 annual additions, for 1700 IBM engineers and scientists. They use the system by filling out interest profiles and are then sent all articles or reports which match these stated interests. The system is able to answer inquiry searches within 48 hours.[3] North American Rockwell has developed an internal system called EDICT (Engineering Document Information Collecting Task) to keep its engineers up to date on corporate-wide design changes.[4]

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[1] New York Times, January 8, 1967 and June 1, 1967. See also National Library of Medicine: A Guide to Medlars Services, Bethesda, Maryland, November 1966.

[2] New York Times, May 31, 1967.

[3] O. Allen Merrit and Paul J. Nelson, "The Engineer-Scientist and An Information Retrieval System," Proceedings, Spring Joint Computer Conference, 1966, pp. 205-212.

[4] New York Times, February 10, 1966.

Recent Efforts to Develop Computerized Libraries

With possibly one exception (Project INTREX at M.I.T.), most of the published reports of computerized library efforts indicate that these are only in the planning stage. The reality is quite different from the "vision," as projected by Professor Kemeny in the citation mentioned earlier. Among the preliminary reports are the following:

1. Project BALLOTS (Bibliographic Automation of Large Library Operation Using Time Sharing) at Stanford University has been supported by a grant from the U.S. Office of Education. This envisages a university-wide library system, which will eventually be a part of a national library communication network. A 1967 report stated that "within three to five years, some 50 terminals will be attached for remote access."[1]

2. The Yale-Harvard-Columbia medical libraries computerization project, announced early in 1965, was dropped because Harvard withdrew. Yale has continued to catalog titles, but on-line or even off-line information retrieval is still in the distant future. The data base is initially being used for catalog card production and accession lists only.[2]

3. Beginning early in 1966, the New York Public Library was the center of a study financed by a grant from the Council on Library Resources. Among the possibilities explored was "an index stored in a computer that would flash book references on display consoles or produce them in print upon the coded request of a librarian.[3]

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[1] "Stanford Undertakes Big Library Project," Datamation, September 1967, p. 98.

[2] "Ups and Downs of Information Retrieval," Datamation, January 1968, p. 129.

[3] "Public Library Weighs Revising Outmoded Index," New York Times, April 17, 1966. For a full account of this proposal, see Library Catalogs: Their Preservation and Maintenance by Photographic and Automated Techniques, James W. Henderson and Joseph A. Rosenthal (editors), The M.I.T. Press, Cambridge, Massachusetts, 1968, Part II, Chapter B, Section 5, pp. 91-117.

4. M.I.T.'s Project INTREX (Information Transfer Experiments) is, as the acronym suggests, still experimental. Beginning in 1965, its announced objective was "to provide a design for evolution of a large university library into a new information transfer system that could become operational in the decade beginning in 1970."[1] The logical bases for Project INTREX were discussed fully at a 1965 Planning Conference. The "university information transfer system of the next decade" was expected to result from a confluence of "three main streams of progress":

> "(a) The modernization of current library procedures through the application of technical advances in data processing, textual storage and reproduction;
>
> "(b) The growth, largely under Federal sponsorship, of a national network of libraries and other information centers;
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> "(c) The extension of the rapidly developing technology of on-line, interactive computer communities into the domains of the library and other information centers."[2]

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[1] As reported in a book growing out of Planning Conference held in September 1965, with participants from M.I.T. as well as other universities and institutions. See Carl F. J. Overhage and R. Joyce Harman (editors), INTREX: Report of a Planning Conference on Information Transfer Experiments, The M.I.T. Press, Cambridge, Massachusetts, 1965 p. xv (Summary). Dr. Overhage is director of the project, which has also involved the M.I.T. Electronics Systems Laboratory under the direction of Professor J. Francis Reintjes, and the Engineering Library, the head of which is Miss Rebecca L. Taggart. Thirty-nine people are listed on the staff roster.

Project INTREX is supported by grants from the Carnegie Corporation, the National Science Foundation, the Advanced Research Projects Agency of the Department of Defense, and the Council on Library Resources.

[2] Overhage and Harman (editors), op. cit., p. xv.

Drawing on what is termed "the on-line intellectual community," using time-sharing computer systems based on the Project MAC experience at M.I.T., the Conference Report visualized "a time when men who work mainly with their brains and whose products are mainly of information will think and study and investigate in direct and intimate interaction with extensively programmed computers and voluminous information bases." Peering further into the future, the Report continued:

> "The prospect is that, when several or many people work together within the context of an on-line, interactive, community computer network, the superior facilities of that network for expressing ideas, preserving facts, modeling interaction with the same information and the same behavior--those superior facilities will so foster the growth and integration of knowledge that the incidence of major achievements will be markedly increased."[1]

This type of system would be more than a computerized library system, for it can also serve the scholar as he prepares his research report or "manuscript." "The report is typed just once--when the author writes the initial draft," in the system of the future. "Because editing with the aid of the editing program is quick and easy, and because the current approach to computer 'understanding' of natural language is more demanding than human readers are for excellence of style and rigorous adherence to stated conventions, important articles are revised and revised." The Conference Report continues:

> "In the on-line community, publication is a multi-state process. Even while a manuscript is in prepartion, it can be as accessible to the on-line colleagues as the author care to make it so."
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> . . . . .
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> "When it is ready for more formal publication, the author may submit his manuscript to any journal that operates within the network.... Editors use the network in their communications

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[1] Ibid., p. 26.

> with reviewers, and that speeds up the review process.... Publication in a good journal within the network carries some guarantees of accessibility."[1]

For future use of scholars, the report "is not stored all in one place. The title, abstract, references, etc. are held in a more readily accessible file than the body. Keyed to the body (and to some of the figures) are sets of data. The sets of data are stored in a data bank."[2]

The publishing potential of an on-line computer system, however, was not the main thrust of subsequent work on the INTREX project, even though it was discussed at the Planning Conference in 1965. This disclaimer was specifically mentioned in the Project's March 15, 1968 Semiannual Activity Report, which reiterated what Project INTREX "really is": "It is a program of experiments intended to provide a foundation for the design of future information transfer systems. We visualize the library of the future as a computer-managed communications network, but we do not know today how to design such a network in all its detail."

More recent developments were reported in the September 15, 1968 Semiannual Activity Report, preceded by the Director's candid comment: "As in most research undertakings, the pace has been less heroic than the vision of the planners. We had hoped to achieve the major goals of the plan by 1968, but it now seems unlikely that we shall reach that stage before 1970." One reason for the longer time required was "the decision by M.I.T. to pursue Project INTREX within the normal academic environment,

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[1] Ibid., pp. 36-37

[2] Ibid., p. 37. See also Appendix B, "An On-Line Information Network," by J.R.C. Licklider, pp. 147-155. See also Appendix G, "Data Archives and Libraries," by Ithiel de Sola Pool, pp. 175-181. If "the storing of basic data in retrievable and manipulable form is...a library function, ...then clearly data archives also belong in the library." pp. 180-181. Under Professor Pool's direction, a beginning in building such data archives for the social sciences, using Project MAC, is underway at M.I.T.

rather than establish a special activity outside the regular university structure." Thus, the Electronic Systems Laboratory and the Engineering Library were the center of the experiment, which has involved faculty and students along with the research staff. Regular users of the Engineering Library are beginning to experiment with the Project facilities being developed there. At the same time, the traditional library facilities are also available, and this blend "will be characteristic of university libraries in the next decade," according to Project INTREX's director, Dr. Carl F.J. Overhage. Six months later, his Report introduction called attention to the possibility of national networks:

> "Information transfer networks of national scope have been increasingly under discussion, and one can see the emergence of a pattern in which systems serving specific fields and purposes will come into existence and grow until the necessary organizational and technial steps are taken to assemble them into an integrated national network. In the meantime, the individual systems will constitute information resources of great importance to the scientific and technical community, and no research library can fully serve its users without putting these resources at their disposal."[1]

The present INTREX system is described as "an experimental pilot model machine-stored library system," and it became operational around April 1, 1969. Initially, less than 10 users had access to the interactive time-shared system under carefully controlled conditions. The main components of this pilot model are:[2]

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[1] Project INTREX, Semiannual Activity Report, March 15, 1969, p. 2

[2] This information is based on material presented by Professor J. Francis Reintjes and his associates in the Electronic Systems Laboratory at the Industrial Liaison Symposium on "Display Technology" at M.I.T., November 14, 1968, and subsequently checked with Professor Reintjes in March 1969. Fuller detail on the Electronic Systems Laboratory work for Project INTREX is found in Semiannual Activity Report, September 15, 1968, Project INTREX, M.I.T., pp. 5-66, as well as in the March 15, 1969 Report.

1. An augmented core-memory catalog containing key words, abstracts, and bibliographical references from about 8,000 journal articles, reports, theses, and books which have been recommended by faculty members. Only about 1,000 items had been stored by April 1, 1969, pending reprogramming to reduce costs. Supervised student-indexers have been used.

2. Information storage and retrieval programs, developed for use on the present M.I.T.-modified IBM 7094 time-sharing computer system. This will enable further experiments on storage and retrieval to be made in the context of a planned 10,000-document augmented catalog and a selected group of users. The system permits an interactive dialog between the user and the system, narrowing down the search to documents which the user really wants or needs.[1] An "INTREX Guide" is provided for users, and there is a built-in monitoring system to observe problems users have with the system; and users can also file comments about the system.

3. A user console with a special cathode-ray tube display. This user console had to be built in the Electronic Systems Laboratory because there were no commercially-available consoles to meet the requirements of the system. Other consoles will be built subsequently, and in the mean-time typewriter consoles are also used.

4. A text access program, with reproduction of photographic images of full texts through a special microfilm printer.

All of these experimental parts of the pilot model system have required considerable engineering and programming work. As one experienced librarian sympathetic to this effort and familiar with it observed, "The young Turks who run the computer show have grown wiser, and the problems have proved more difficult than they anticipated." Finally, in addition

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[1]For a sample dialogue, see Fig. B-3, <u>ibid.</u>, pp. 15-18.

to the INTREX experiment, the M.I.T. Library System has a separate program of studies in computer-based systems. A system for the entire acquisition process was reported as 80 per cent complete in March 1969, providing status reports on acquisitions up to the cataloging step. A second system in the design stage will provide computer production of catalog cards in the M.I.T. Science Library. The third effort, computer control of the serials and journals list, is operational but a failure because the technology and the software were not ready to do the editing, alphabetizing, and merging of lists required.[1]

This section on recent developments concludes with the observation that progress has been slower than anticipated, but the computer-based "library of the future" in large university and national libraries is not more than another decade away. The experience of Project INTREX has been reviewed in some detail because it suggests the direction in which these efforts are going.

Some Implications of Computerized Information Retrieval Systems

Some consequences of computerized information retrieval and transfer systems have been suggested in the preceding discussion. These and other implications can be summarized under the following points:

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[1] This information was drawn from a talk on "The computer and the M.I.T. Libraries," by Dr. Myer M. Kessler, Associate Director of the M.I.T. Libraries, at an Industrial Liaison Symposium, "Libraries and Information Resources," at M.I.T. on March 5, 1969.

1. The library of the future "will be the central resource of an information transfer network that will extend throughout the academic community." Not only will books, periodicals, and documents in the library be retrieved by the user through the system, but he will be able to communicate with others through the network, and also gain access to the university's total information resources (including data banks). "Long-distance service will connect the university's information transfer network with sources and users elsewhere."[1] This would include access not only to other libraries and to a national library (such as the Library of Congress), but also to library and information resources in other countries.

2. Before such a system is in full operation, a large number of "expert filter" or subject-matter specialists must be attracted to assist in library-oriented activities, and thus provide the necessary intellectual input into the system.[2] Possibly full-time specialists in each field will be so attracted; but interim solutions with incentives for part-time participation may be necessary. In other words, scholars in each special field will have to be given rewards for time spent in "filtering" the voluminous specialist literature for inclusion in the system, with suggestions for cataloging, indexing, etc.

3. While in the long run the new system may reduce the need for new human librarians and library personnel such as catalogers, book selectors, and book replacers, the system will not really be labor-displacing

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[1] Overhage and Harman (editors), op. cit., p. 1.

[2] Ibid., Appendix T, "More on the Expert Filter," by Stanley Backer, pp. 275-76.

in any real sense. The national shortage of trained librarians will still confront small non-computerized libraries, and compel those in the new system to utilize those they hire more effectively. So, while this will not be their primary result, computerized libraries will also relieve library staffs of the routine and repetitive tasks of duplicating materials and preparing catalog cards for new acquisitions.

4. The main effect on library staffs, however, will be to enlarge their responsibilities. "Certainly, the librarian of 1975 will be less involved than now with the individual transaction between user and book.... The librarian will be of primary importance in the acquisition of new material, in cooperative cataloging, in organizing the collection, instructing users of the library, and in modifying the rules and programs to maximize the services provided to the user over the long run. The librarian will be able to operate with greater freedom by having control over advanced machinery. The librarian will be much involved with the arrangement of channels with other libraries and facilities....It seems likely that to be a librarian in 1975 will be very fruitful and exciting."[1]

In summary: "It seems likely that the librarian will gain immense new powers to shape and organize the corpus of his library once the huge burden of repetitive manual techniques has been removed."[2]

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[1] Ibid., p. 50.

[2] Ibid., p. 55.

5. This longer-range future for library staffs will be reached only after systems design and implementation takes into account the sensibilities, concerns, and even fears that present library staff people may have for the "library of the future." In its prototype system at the Engineering Library at M.I.T., Project INTREX has worked with the staff of that library; and directors of the project emphasize that great attention has to be paid to the users of the new system, including the library staff. Indeed, one of the objectives of the experimental computerized library is to understand better the human reactions and interactions, both of the users and of the librarians. Despite all the claimed advantages, resistance to change will occur if those being changed are not consulted and involved in the design and development of the new system. This applies no less to libraries than it does to education or other knowledge industries, as well as to computer applications in management (where there has been a longer history of both resistance to change as well as successful introductions).

6. For the user, the computerized library as developed by Project INTREX and similar systems offers the advantages of a man-machine interactive system. With remote access terminals, the scholar can query the computer on a particular broad sub-field, and by narrowing down the topic through queries and replies, come up with what he needs. These references can then be printed out, either in abstract or full text form, or used in microfilm form. The dialogue between the user and the computer is central to this concept of on-line information retrieval and transfer. In a fully-developed system, it should also permit cross-referencing to related fields, since knowledge is multi-dimensional.

7. While "browsing" by machine seems possible under such an interactive system (assuming that time in an on-line system is available for this), in another sense true browsing is not possible by machine. The scholar in humanities or social sciences who now prowls the library stacks looking over books catalogued in his special field can now open a book and sample it quickly. Will he be able to do as well in a computerized system which has, as one of its objectives, eliminating the need for enlarging book-filled libraries? Such a scholar needs time to examine carefully books or monographs; to take them to his desk or study; to look for related or conflicting theories, concepts, and facts; and to use them in his initial draft of an article or a monograph of his own.[1]

Thus, there would seem to be a place for conventional libraries of some type, even in the "library of the future." Of course, certain reference works will always be available as books, and students presumably would still have access to books "on reserve" for particular courses of study. Open shelves for "browsing" by students at the college level ahould never be replaced by a computerized system. In short, there would seem to be a place for some part of present libraries along with the new computerized system.

8. Since many libraries will not benefit from the new systems as as early as some, there is a danger in having students and other users familiar only with the new system, when they will be poorly prepared to use the "Model-T" libraries they find elsewhere. This is an additional reason why, for some period of time in the future, even a university library system may well have both the new and the traditional libraries used for different purposes by students, faculty, and other users.

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[1] See Appendix M, "How Humanists Use a Library."

9. As noted earlier, it is important that for an extended period there be provision for user reaction to the new systems. Since the purpose of any computer-based system is to enable scholars to work more effectively, the feedback from the users will enable the system to be progressively improved. This point was extensively discussed in the Project INTREX conference. The system itself will record the experience of each user, but additional ways must be found "to keep open the informal channels of communication with the users."[1]

10. A final implication of the new information retrieval and transfer systems involves the question of reproduction of published materials. Publishers have been especially concerned about this.[1] As one publisher's representative put it at the INTREX conference, "The evolving computer technology is apt to upset the 'balance of nature' in the subtle area of the relationship between the author and his brainchild."[3] Many authors want a published end-product, with adequate acknowledgement and in some

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[1] "The combination of the computer with remote copying technology will make some types of publications obsolete, such as scholarly journals, symposia, and certain kinds of reference works....There is danger that the new technologies will have something like the same effect on books." Herbert S. Bailey, Jr., "Book Publishing and the New Technologies," Saturday Review, June 11, 1966, pp. 41-43. Mr. Bailey is Director of the Princeton University Press.

[2] Appendix J, "The Motivations of Authors--Intellectual Property and the Computer," by E. S. Proskauer, in Overhage and Harman (editors), op. cit., pp. 199-201. For a full account of the publishers' position, and an evaluation of the problem, see The Copyright Law as It Relates to National Information Systems and National Programs: A Study by the Ad Hoc Task Group on Legal Aspects Involved in National Information Systems, by the Committee on Scientific and Technical Information, Federal Council on Scientific and Technical Information, Federal Council for Science and Technology, Washington, D. C., distributed by the Clearinghouse for Scientific and Technical Information, Springfield, Virginia, 1967.

[1] Appendix C, "Measuring User Needs and Preferences," by George A. Miller, in Overhage and Harman (editors), op. cit., pp. 156-158

cases monetary remuneration. If their publications can be reproduced for users of the new system directly, there is a possibility that these users will not purchase hard copies or subscribe to journals themselves. An example of what is already happening is the extensive photocopying of published and copyrighted material for individual and class use as well as for other dissemination purposes.

With reproduction facilities being an extensive part of thenew system, and the further possibility that some research reports filed directly in the system may never be "published" in the traditional sense, the effect on traditional sources of scholarly publication and dissemination--to say nothing of traditional publication methods--will be substantial. It is unlikely, however, that resistances from the traditional sources can do any more than delay the eventual development of the national and international systems of scholarly information retrieval and transfer. But in the meantime, there may well be extensive litigation between reproduction of copyrighted materials in computerized retrieval systems.[1]

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[1] A book published in March 1969 by a major publisher carries the following notation: "Copyright 1969. All rights reserved... No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, or otherwise, without the prior written permission of the publisher."

III

LEGAL, LEGISLATIVE AND RELATED SERVICES

The application of computers to legal services and legislative services, the administration of justice by courts, crime prevention and law enforcement is scarcely five years old. Most of the references to initial experiences begin around 1965 or 1966, but there is now a growing literature on computer applications and the possibilities for future applications in these related fields. The discussion below will take up each in turn.

Legal and Legislative Services[1]

The application of computers in these services has encountered some resistance for at least two reasons: (1) law is a profession rooted in the past and older lawyers in particular are accustomed to traditional ways of retrieving information, and (2) many law firms are small and lack the resources to utilize the new technology effectively, and furthermore, the prestige law schools have not introduced computerized information retrieval systems, although some of the less well-known ones (such as Pittsburgh and Nebraska) have begun to do so. Generally, as one lawyer put it, the legal profession seems to have a "show me" attitude about computers.[2]

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[1] This section has benefitted from interviews and discussion with Robert P. Bigelow, Esq., of the law firm of Hennessey, McCluskey, Earle and Kilburn, Boston. Mr. Bigelow is editor of the book, Computers and the Law (a publication of the Special Committee on Electronic Data Retrieval, American Bar Association), Chicago: Commerce Clearing House, 1966.

[2] Quoted in the New York Times, February 5, 1967.

The Need

Good reasons for turning to computerized legal information retrieval systems already exist, however. The low-paid "law clerk" (the recent law school graduate) is fast disappearing, with New York law firms now offering starting salaries of $15,000 a year, compared to $1,500 a decade and a half ago. His services in routine checking of precedents and legal references are now much more expensive than formerly. At the same time, the "information explosion" is hitting the legal profession as well as others. The flow of new court decisions, statute law, rulings by administrative agencies, and law review articles is inundating the average lawyer or law firm. Law libraries of the Library of Congress and the universities are overwhelmed by requests for photographed copies of laws not available in the typical law firm's library.[1] Finally, law firms face the same need as business firms for reduction of office costs associated with time records, billing, accounting, and collection procedures. The computational problems in trust administration are also serious.

Early Efforts

One of the first publicized efforts to develop a computerized legal information system was made by Dr. John F. Horty, then Director of the Health Law Center at the Graduate School of Public Health, University of Pittsburgh.[2] He had started to investigate computer possibilities in 1959, and the Center got its own computer in 1962. By early 1965 he had

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[1] New York Times, October 10, 1967.

[2] As reported in "Computers Do the Digging," Business Week, January 23, 1965. See also article by Horty, "The Use of the Computer in Statutory Research and the Legislative Process," in Bigelow (ed.) op. cit., pp. 48-55.

on tape the statutes of Pennsylvania, New Jersey, and New York; the City of Pittsburgh ordinances (which had been coded earlier for another computer application and which incidentally uncovered numerous duplications and inconsistencies); the appellate court and Supreme Court decisions of the Commonwealth of Pennsylvania; and all Pennsylvania statutes relating to welfare. In describing his system, Horty commented: "The computer is nothing more than a meticulous, careful but not very bright law clerk. It will give you back only what you ask it for."[1]

The first commercial system was apparently developed by Law Research Service, Inc., of New York. Although started in 1964, it was not able to develop a national on-line system until 1966, when it then provided access to some three million case references stored in a Univac 418 system. Eventually, the system is expected to cover all rulings in federal courts and in 15 states. Each lawyer-user had his own 10-digit code, with each inquiry costing $10-15, plus the cost of the Telex line and outlet rental in his office.[2] There are no published reports on the extent of use.

Recent Developments

In the meantime, the Horty effort in Pittsburgh shifted to the University of Pittsburgh Law School, offering lawyers inquiry service for

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[1] Ibid., p. 50.

[2] First reported in Business Week, January 23, 1965, and subsequent notes in Datamation, February 1966 and May 1966. Another special service is offered by the Lawyers Center for Electronic Legal Research, which in 1967 planned to computerize Federal Tax laws, then expand the file to include tort and contract law. The planned charge was $25 per question, using key word descriptors. New York Times, February 2, 1968.

the statute law of 50 states, plus U.S. Supreme Court decisions, some appellate and some state supreme court decisions. There was no charge, but users were urged to make contributions to the law school.[1] Subsequently, reports indicate that the service was changed to a privately-owned commercial one, available to law firms via remote teletype terminals. Inquiries are logged into the computer in Pittsburgh, and answers returned over the teletype to the user's location.

Other recent computer applications include the following:

1. An estate planning service designed "to bridge the information gap" between growing cases and laws and the lawyer's ability to handle them in estate planning. The system claims to do necessary calculations faster, thus providing better service to the client.[2]

2. Preparation of wills through a system developed at the University of Wisconsin in cooperation with a Madison attorney. This experimental system has a "conversational machine interviewing" program to gather data from the client in the law office. The system then manipulates the data through a will-draft algorithm to select required will clauses from the library file and prints them with appropriate inserts from the interview procedure. The first test

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[1]New York Times, July 12, 1967

[2]This service is offered by COAP (Computer Oriented Analyses and Planning), Greenvale, Long Island, New York.

of the system showed that simple wills could be printed in about 30 seconds.[1] As in estate planning, the lawyer-client relationship is preserved, for the system is planned for use in the lawyer's office, where he can explain the results in "lay terms."

3. Trust administration--a large Boston law firm is programming a computer for this type of work, which requires complex record keeping. It is already being used for office administration, time records, billing etc. According to available information up to late 1968, this was the only law firm in the United States with its <u>own</u> computer.

4. State legislative retrieval systems are being developed by several states in cooperation with the Aspen Corporation, the commercial corporation developed by Professor John F. Horty at the University of Pittsburgh.[2] Among the first states to experiment with systems for retrieving legal information for legislators were Iowa and Florida. The Iowa system claims to provide overnight delivery printouts of requested sections of Iowa laws and the state constitution, identified in the inquiry by key words and phrases. The

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[1] Letter from Professor Richard W. McCoy, Director, Data Processing Center, School of Business, University of Wisconsin, September 15, 1967. Attorney William Chatterton, of Madison, worked with Professor McCoy in developing this system.

[2] The corporation is owned largely by the University of Pittsburgh. States cooperating in the "experiment" will summarize research reports on about a page in a special type face, which can be read by a special optical scanning machine and stored on magnetic tape in the centralized data bank in Pittsburgh. <u>New York Times</u>, April 7, 1968, p. 14.

Florida system can locate every piece of legislation filed and make available daily all actions on each bill through the previous day's session, printed out in terminals in the State Capitol. The Home Rule Commission of the Massachusetts Legislature has recommended a system to provide legislators with actions on all pending laws (as in Florida), as well as codify existing laws.[1]

5. Computer-aided abstracting of legal information - Project LITE (Legal Information through Electronics), U. S. Air Force. A shortage of human abstractors led to an experimental system which uses significant index words to prepare an abstract or extract of an entire body of text. The system provides an abstract which compares favorably with a human abstract, provided the author "has set form clearly and explicitly the main points" of his article.[2]

Implications

Legal information retrieval systems will free lawyers from time-consuming work in checking legal sources, if they can overcome their resistance to using machine aids. The increasing salaries of law school graduates may force large firms, at least, to use computer-aided legal

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[1] James Kelly, Chairman, Home Rule Commission, Commonwealth of Massachusetts, unpublished paper. The system is not yet operational. Indeed, Massachusetts was reported as the latest state to use computer systems. See Automation in State Government, 1966-67, A Second Report on Status and Trends by the Council on State Governments and the Public Administration Service, Chicago, 1967. The main use reported by states is "to handle the repetitive mass of administrative transactions, tedious but inescapable, that are the chief business of modern government." p. 26.

[2] Jack Sieburg in Datamation, November 1966, p. 65.

searching systems. Young law clerks may better use their talents in preparing abstracts for the computer storage file, and some may be hired by computer utilities specializing in legal search rather than by law firms as such. Probably only very large law firms would develop their own computer capabilities.

Other computer systems for estate planning, will preparation, and trust administration and real property records will free lawyers from routine and repetitive work, or tasks requiring mathematical calculations which are now performed with calculating machines much less efficient than computers. As the computer takes over these tasks, the lawyer will be freed for more constructive work on clients' problems, including the personal consultation necessary to maintain the valued lawyer-client relationship. It is not clear, however, that computer systems will bring down costs sufficiently to reduce legal fees, or reduce the amount of time necessary for preparing briefs or court presentations. Possibly the best that can be hoped for is that fees and legal delays will not increase as fast as they would have otherwise.[1]

A more visionary view of computer impacts on the legal profession is the following: "The computer will soon achieve such universal use in law research as to revolutionize the practice of law and the processes of legal systems."[2] Another lawyer in the forefront of computer applications in law has claimed: "The use of computers to retrieve legal information

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[1] One computer-based service for estate administration advertises that it will justify the lawyer's charging higher fees because the client will get better and faster service!

[2] Charles S. Ryhne, former president of the American Bar Association, quoted in the New York Times, July 10, 1967: he referred to a "shortage of lawyers."

is the most important change in the administration of law since the advent of written law reports."[1] In another context, Merrill Flood has suggested that trial work would be speeded up because "legal information networks might...be interrogated even during trials," and consequently "the need for complete preparation of evidence in advance would be reduced, since the essence of every decision process is a sequential set of steps that eventually lead to an answer to the basic question."[2]

In the nearer term future, other impacts on the way law firms are organized and the way in which legal counsel is sought may be suggested. If legal information retrieval systems are developed through computer utilities specializing in the legal and legislative field, the law office may well be organized differently than it is today. Smaller firms will not need to have extensive law libraries; they can interrogate the computerized legal centers for most purposes, and get facsimile copies of certain references after checking the texts through visual displays as a part of the computer system. The impact of this on law book publishers is not difficult to foresee, although legal problems over copyrights may well delay eventual facsimile copies through a computer system. In any case, one speaker at a special American Bar Association conference in 1965 made this prediction:

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[1] Thomas C. Plowden-Wardlaw, tax lawyer and vice president and executive director of the Lawyers Center for Electronic Legal Research, quoted in New York Times, February 5, 1967.

[2] Report of the National Commission on Technology, Automation and Economic Progress, Appendix Volume I, "Commercial Information Processing Networks—Prospects and Problems in Perspective," pp. 237-252.

"Eventually I foresee that we will have specialized service bureaus located in key cities and with the law office, with facsimile equipment, communicating into these service bureaus or legal centers and getting results back from them."[1]

Whether these separate centers will become part of a truly national system in the United States is less certain. Present partial systems use different descriptors to search the files - key words, phrases, etc. Possibly a "full text" approach would permit a national system, but the question of financing the planning and implementation stages is more difficult. Given the present conservatism of the legal profession toward computer systems, a national system seems far away.

A final implication concerns the access to such legal information retrieval centers. Will it be confined to the legal profession only — or can others check statutes and court decisions on matters of concern to them? One example would be those concerned with public policy issues, or with research on topics which impinge on the law (e.g. an economist studying anti-trust policies, or aspects of labor law). This is now common in law libraries and published legal services; it seems unlikely that computer utilities specializing in legal information will refuse access to laymen. But once the door is opened, the practice of law may change. Laymen may become their own "lawyers" on routine problems, despite the risks.

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[1] Raymond J. Long, "Non-Conventional Systmes for the Law Office," Proceedings, Special American Bar Association Conference, 1965, p. 29. A nation-wide system in Belgium was in the planning state in 1967, to service the many one-man law offices, as well as judges, "many of whom deliver opinions without full knowledge of legal precedents because they cannot afford the time to look up the law in the only complete law library in the country, in Brussells." New York Times, February 28, 1967.

Another possibility is that centralized legal information retrieval centers, manned by a lawyer and many computer operators, may provide inexpensive legal aid services to poor people who normally cannot afford traditional legal advice in law offices. It is not difficult to conceive of such centers providing information on applicable rent laws and city ordinances, drawing up wills, processing routine legal complaints, etc. Centers of this type are likely to be financed by public funds in central city areas, rather than by private enterprise.

When the implications of legislative uses of computer systems are considered, it is clear that non-lawyers among the legislators will have the same access to statutes, decisions, and progress of bills through committees and on the floor as do the legislators who are members of the legal profession. These systems will undoubtedly facilitate the work of those legislators who now have great difficulty keeping abreast of past and current legislation. Preparation of new bills will certainly be easier, especially if the computer file can be queried as to related and relevant statutes, court decisions, and other bills before the legislative body. It is difficult to see why legislators would oppose the development of such systems, but the fact that only a few states have them in operation or even the planning stage attests to the same conservatism about trying new methods which seems to characterize the legal profession. Part of this conservatism may be explained by the costliness of systems designed for a particular state.

The application of computer systems in the Federal government is further ahead than in state governments. Cost-effectiveness studies

in the Defense Department have drawn upon computer technology, as have other federal departments in their work, particularly in the Planning-Programming-Budgeting System. But Congress has lagged behind, even though in January 1968 the American Law Division of the Legislative Reference of the Library of Congress installed an on-line terminal system to record and store bills and resolutions introduced in the 90th Congress.[1] Other uses were visualized, as an aid to Congressional deliberations, including daily print-outs summarizing the previous day's congressional action, vote summaries, status of legislation pending in committees, etc. As Congress develops these systems, and as the Executive Branch develops its computer-based decision-making power further, the question of who has access to what information will become more complex. Can the separation of powers concept be maintained, or will Congress "tap into Executive-based information systems....and develop more limited information systems for its own specific requirements."?[2]

Administration of Justice

We have noted earlier some of the resistances to computers in legal and legislative services. Similar factors account for the fairly limited application of computers in our court systems. As Chief Justice G. Joseph Tauro of the Superior Court of the Commonwealth of Massachusetts has said: "We dare not proceed with undue haste even though we can't

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[1] John S. Saloma, 3d, "System Politics: The Presidency and Congress in the Future," <u>Technology Review</u>, December 1968, pp. 23-33. This article was adapted from the author's forthcoming book, <u>Congress and the New Politics</u>. See also Robert L. Chartrand, "The Potential of Information Technology in Congressional Activity," Legislative Reference Service, Library of Congress, Washington, D. C., February 14, 1968.

[2] Saloma, <u>loc. cit.</u>, pp. 32-33

hesitate to move ahead. Law is conservative and we must anticipate opposition to realignment of court procedures and functions. So we must proceed slowly or face failures through opposition."[1] But the need for computer assistance is growing.

The Need

Overcrowded court calendars, causing delays in scheduling which have spiralled, are compounded by present manual scheduling methods which often result in idle courtrooms and judges. Selection, time accounting, and compensation of jurors by present methods adds to delays and is cumbersome. Some cases coming before courts are routine, such as parking and traffic violations. The explosion of court records has overwhelmed human clerks in many jurisdictions; present filing and indexing procedures often tie up needed court records.

For example, Judge Hayden of the Los Angeles County Court pointed out that in 1963 civil cases totalled 800,000, yet these were inaccessible unless the court knew the case number or case title, by which each was indexed.[2] Or, as Chief Justice Tauro put it, a better method of retrieving data on each case is necessary for effective judicial administration, such as referral of cases to masters, auditors,

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[1] Informal talk at Conference on Computers, Courts and State Government, sponsored by the Committee on Automation of the Boston Bar Association, May 17, 1968.

[2] Talk at Fall 1963 Joint Computer Conference. For a corroborating view, see Norbert A. Holloran, "Modernized Court Administration," Appendix E in Task Force Report: The Courts, The Task Force on Administration of Justice, The President's Commission on Law Enforcement and the Administration of Justice, Washington, D. C., 1967. "Court clerks sometimes view themselves more as court archivists than court administrators, and case history sheets frequently are designed to do little more than accommodate historical purposes." p. 164.

Recent Developments and Plans

The available literature reviewed above contains more proposals for future developments than reports on existing ones. Among those possibilities mentioned in a paper on "Court Congestion," are computerized judicial data centers, an automated civil docket, and an automated criminal docket.[1]

More specifically, the following are the areas in which computers have already or might speed up court procedures:

1. Better scheduling of court dockets, to utilize more efficiently judges and courtroom space, to prevent attorney conflicts on two or more scheduled cases, and fruitless appearances of witnesses, jurors, and others involved in scheduled cases.[2]

2. Improved preparation of court docket records, including case histories, documents, and other statistical material.

3. Rapid duplication of court forms, which are now rewritten and copies by court clerks, with possible errors as well as bottlenecks in movement of information through the judicial system.

4. Better indexing of cases, providing cross-indexing by parties' names to docket-number or case-number (the usual index). In 1963 it was

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[1] Halloran in Robert P. Bigelow, Editor, Computers and the Law, a publication of the Special Committee on Electronic Data Retrieval, American Bar Association, Commerce Clearing House, Chicago, 1966, pp. 67-72. For a similar longer discussion, see Halloran, "Modernized Court Administration," Task Force Report, Appendix E, 1963. Much of the information in this section was drawn from this report.

[2] Halloran reports that in one major city, "the trial call for one day showed 76 cases called with only 12 able to go on trial. Most of the others had attorney conflicts. Ironically, there were 14 court vacancies that day, so two courtrooms stayed empty even though thousands of aging civil cases were backed up awaiting trial." Op. cit., p. 166.

stated that "Indexing is one of the clerical tasks that most court clerks agree ought to be mechanized. Probably from 10 to 20 courts in the country have adopted a punched card indexing system." But, "a completely automated docket file would be self-indexing.... the computer printed docket would arrange case summaries in alphabetical order. Thus the two big, historically separate docket records--index books and case history books--would become one. It would no longer be necessary when looking up a case to find its number first. Knowing its name would be enough."[1]

5. Better juror management, through using computerized files to select prospective jurors from a file of names; preparation of juror notices; accounting for time served; and preparation of compensation checks.

6. Assignment of counsel from a computer file of local attorneys to defend indigents or those accused in criminal cases. The Houston Legal Foundation, a legal aid organization, used a rented computer service to keep information on 3,600 practicing lawyers and programmed the machine to match an attorney's experience to the specific case.

7. Possibility of a system for assisting higher court judges in reviewing judicial appeals, based on precedents. The program would help the court search precedents.[2]

8. Possibility of a program which would (a) provide more uniformity of sentencing in a large court system, and (b) enable attorneys to "predict" the likelihood of a particular decision from a court or a judge, based on past judicial rulings there.

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[1] Halloran, op.cit., p. 170.

[2] *New York Times*, March 22, 1967.

conciliation, or assignment to specific judges. The present method is "guesswork supported by experience" - a manual method which often takes weeks, and even months. Finally, there is a lack of uniformity of sentencing practices in large judicial systems, because rapid information retrieval is lacking. When 120 judges sit in the Superior Court of Los Angeles country, sentences for similar cases sometimes vary, according to Judge Hayden.

First Steps

Initial machine applications did not involve computers. Starting in 1964, the Los Angeles County Court system used punched cards and an IBM electronic counting machine to reduce its case backlog by better scheduling. It was finally converted to a computerized system in 1968, based on work done by the Systems Development Corporation and the Law Research Center of the University of California at Los Angeles. The Pittsburgh and San Diego court systems have also used punched card systems for scheduling trial dates in civil suits.

As early as 1963 Denver used computers for preliminary scheduling of civil and criminal cases. One of the busiest trial courts, the Supreme Court of New York County, planned about the same time to computerize trial scheduling. "Computer advantages over punched card equipment for scheduling include a tighter and more current control of information about attorney commitments, case settlements, and courtroom availability."[1] But they appear to be economically feasible only in large court systems, or metropolitan areas where a central computer can also be used for other governmental purposes.

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[1] Halloran, op. cit., p. 167.

Some Implications

Computer applications in the court systems would clearly relieve clerical personnel of present routine, repetitive tasks. In fact, these would be performed more accurately, and with less delays, than at present. Case scheduling would be improved, court delays reduced, record keeping more accurate, and better access to cases provided through better indexing. An additional advantage of case scheduling by computer is that it would be depersonalized, not subject -- as humans might be -- to influece in scheduling preferences, or blame for errors and delays.

Will these computerized programs reduce the need for court clerical jobs, which are often sought because of job security, or for political patronage reasons? Some may be displaced, although it would seem that their talents might be used to handle problems not in computer programs. Probably the number of clerical personnel hired, especially for routine jobs now handled by the computer, will be reduced. Some cost estimates of the savings from computer introductions in large urban court systems specifically mention substantial "clerical savings."[1]

Even if there is no actual displacement of present personnel, the fear of the new system by those accustomed to old routine ways must be considered by systems designers. As Chief Justice Tauro of the Superior Court of Massachusetts was quoted earlier as saying: "We must anticipate

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[1] Halloran estimates that a computer center for an urban county of one million people, dedicated mainly to justice functions, would cost between $150,000 and $225,000 a year. "This would be offset by clerical savings that might very substantially reduce the cost." Op. cit. (Task Force report), p. 163.

opposition to realignment of procedures and functions." His suggestion was that some court administrative procedures, such as civil docket entries, might first be automated, giving court personnel training in computerized procedures, and involving them in the process, thus reducing their opposition.[1] This is sound advice, identical with the successful experience with computer introductions in managerial functions such as inventory control, production control, and the development of systems of management information and control.[2]

Perhaps opposition will be less from judges themselves. At least one has been quoted as saying: "We judges have no fear of automation as threatening our security of employment." Instead, he welcomed computerized trial scheduling, better preparation of court records, and a computerized index which would enable him to check precedents more quickly. If the data base were kept current, judges could also be provided with information on the status of other cases, as could attorneys interested in them. An on-line real time system would provide this information "instantly" and could also be used for transmitting court orders, summonses, judicial notices, and other documents. It might also provide feedback to judges on what happened to guilty defendents after sentencing, subsequent paroles, and experience under parole.

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[1] Talk at Boston Bar Association meeting, May 17, 1968, cited earlier.

[2] "The only way to guarantee that the system will effectively serve managers as an extension of their intelligence in planning and control activities is to insist that managers influence the design. This is a very serious matter, and it cannot be left to the systems engineer without painful consequences." Zenon S. Zannetos, "New Directions for Management Information Systems," <u>Technology Review</u>, vol. 71, no. 1, October-November 1968, p. 39.

Another implication is improved consistency of judicial decisions, to the extent that any judge could be provided with information on what other judges are currently ruling in similar cases. Prediction of judicial decisions by attorneys appearing before particular courts -- now done anyway by study of such decisions and current gossip among attorneys -- would be improved by better machine retrieval of the pattern of decisions in particular courts. In Superior and Supreme Courts, judicial voting patterns would be monitored, and in criminal cases, sentencing patterns. Whether or not this would improve the administration of justice, it would clearly enable attorneys to prepare their cases with better information about judicial behavior. This is a more conservative view than the following: "Computers can make calculations in a few minutes which would take a man a lifetime to complete. Thus, computers can aid lawyers and the courts obtain greater insight into the judicial making process than has been possible heretofore and can aid lawyers and judges attain speedier justice for the right reasons than heretofore. Computers can help lawyers calculate the odds in their favor, and hence aid lawyers in advising clients on the best course to pursue."[1]

Crime Prevention and Law Enforcement

Police departments attempt to prevent crime, apprehend actual or potential criminals, make arrests, handle traffice and crowds. But the methods used have apparently changed relatively little, despite the use of patrol cars, radios, and central dispatch systems. In 1967, the members of the Task Force on Science and Technology appointed by the

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[1] Reed C. Lawlor, "Analysis and Predictions of Judicial Decisions," in Bigelow (editor), op. cit., p. 60

President's Commission on Law Enforcement and the Administration of Justice, began their study with extensive visits to police departments of major cities, and then commented: "Our visit to the police world was like a trip to another technological century." Chief of Police Thomas Reddin, of Los Angeles, said: "We believe we have the most up-to-date department in the country, but our equipment has hardly changed since I was a rookie in 1941. We are trying to fight the rise in crime with hand-me-downs from our father's generation."[1]

The Need

As in other knowledge-type industries, the information explosion represented by the increase in reported crimes, the greater volume of information on stolen property and wanted persons (not now readily accessible in many cases to local law enforcement officials), confronts police departments. This has resulted in delays and even perhaps fewer arrests and convictions. Crime prevention and arrests appear to be a function of the rapidity with which police patrol cars can respond to a request for help and reach the scene of the crime. The special Task Force of the President's Commission on Crime Prevention and Administration of Justice found that when the response time was one minute, 62 per cent of the cases ended in arrest, but when cases with a response time under 14 minutes were combined, only 44 per cent led to arrest.

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[1] Quoted by George A. W. Boehm, "Fighting Today's Crime with Yesterday's Technology," Technology Review, vol. 71, no. 2, December 1968, p. 51. Parts of this section draw on this article.

The need for a computer-aided "command and control" system, as suggested by the Task Force, is clear. This would reduce present delays in informing patrol cars of reported crimes or emergencies reported to police headquarters, aid in tracing stolen automobiles, apprehending wanted persons, checking suspects or missing persons, and tracing traffice and parking violators who have ignored summonses.

First Steps

When Professor O. W. Wilson of the University of California (Berkeley) was appointed Commissioner of Police in Chicago, he reorganized the Department and began to install a computerized command center in 1962. Subsequently, the system has been developed with third-generation computers to permit operators at computer consoles to maintain instand communication with the patrol cars in particular areas. Policemen can get a 10-second reply on suspected stolen automobiles or for wanted or missing persons, stored in the computer's random access files. The system also provides daily reports to each of 21 field commanders on crimes by type and location in the city. Each field commander can then evaluate his situation relative to all others, and field administrative decisions can be made better.[1]

Another relatively early development was in the New York State Police system. A computer file for storing registration numbers of stolen cars and stolen license plates was developed and tied in with consoles in

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[1] Based on reports in Business Week, January 15, 1966; Datamation, July 1967, p. 52; and Boehm, op. cit. (photographs).

municipal police departments and county sheriff's offices. Answers were provided in 60 seconds.[1]

Later Developments

In addition to the further refinement and expansion of the Chicago system, the following have been reported more recently:

1. A New York City system which reduces the delay in relaying emergency calls from headquarters to patrol cars from 90 seconds to 20 seconds. Police Commissioner Howard R. Leary stated: "Our aim is centralization. More and more emphasis is put on instand communications for tactical purposes."[2] The city has also contracted with a private bank to receive parking fines, and for the use of computerized system which checks the bank's record of fine payments with an outstanding list of summonses and then issues new ones.[3]

2. Alameda County, California, has a Police Information Network (PIN) in an on-line real-time system covering 4 million people (including the city of Oakland). This is also tied in with the Statewide Theft Inquiry System in Sacramento.[4]

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[1] Datamation, December 1965. For a graphic illustration of the case of a Maryland State Policeman's apprehension of wanted criminals through a suspicious out-of-state parked car, determined to be stolen through a 60-second inquiry of a computer file, see Boehm, op. cit., p. 59.

[2] New York Times, August 30, 1966.

[3] Business Week, June 17, 1967.

[4] Datamation, March 1967.

3. A Pattern Recognition and Information Correlation System (PATRIC) has been developed by the Systems Development Corporation for the Los Angeles Police Department, to assist in crime detection. While the department is apparently organized in decentralized field commands, crime data can be processed on a city-wide basis and there is a real-time inquiry system for wanted individuals.

4. The F.B.I. has developed a National Crime Information Center which maintains a computerized file of stolen cars and wanted criminals nationally. State and local systems can tie into it.[1]

5. Philadelphia has recently established a police computer unit, and is planning to schedule patrol car assignments on the basis of a detailed crime forecast covering each part of the city for each hour. With the help of the Franklin Institute, a computer program is being developed to make such predictions automatically.[2]

6. Finally, one major proposal of the Task Force of the President's Commission is still to be implemented in any city. This is "a completely automatic computer-controlled system" for dispatching patrol cars. After a clerk informed the computer of the nature and location of reported trouble, the program would automatically radio commands to the nearest car or cars, cutting response time to a minimum.[3]

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[1] New York Times, January 28, 1967.

[2] Boehm, op. cit., p. 58.

[3] Ibid., p. 57

Implications

If most police work is characterized by methods which have changed very little over a generation, then computers will drastically alter it. But it is a reasonable prediction that some police will be relieved of clerical work, and freed for the work for which they are presumably trained: preventing crime and other law violations, and apprehending actual or potential law violators and criminals. Others will be freed for traffic control duty.

There will be more centralization of "command and control," but if better and more rapid information is provided to field commanders (as in the Chicago system) and to the patrolmen in cars or on the beat, then they too have their jobs made more effective, not less effective. No computer will apprehend a criminal, or prevent a crime; but it may help the man do this in a true man-machine relationship that is likely to be superior to any previous system.[1]

Computerized systems will also result in a better deployment of a costly resource - policemen, who represent as much as 85 per cent of some police budgets. Buf if more is spent for computer hardware, software, and human programmers, the budget proportions may shift, as in Chicago, to 30 per cent for equipment and 70 per cent for personnel. Old-line policemen will have to get used to a new breed: systems designers and programmers who will become more important in the future.

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[1] An IBM advertisement puts it this way: "Computers don't make arrests. But in a split second, they can give the policeman his most effective weapon against crime---information."

As one speaker at the Fall Joint Computer Conference in 1966 put it: the problem "of implementing an effective systems analysis into the urban management context will be two-fold (1) to obtain cooperation for a full, rather than a piecemeal, systems effort; and (2) to devise a communication and control system that adequately reflects organizational objectives." But there is likely to be resistance by the public manager, including some police commissioners, "whose natural aversion to change is reinforced by statute, code, administrative and civil service regulations."[1]

A further source of resistance may be the fear that greater centralization of files will present a security problem. According to Business Week, "The FBI is appalled by the prospect that organized crime might sabotage a national computer, or dig information out of it for blackmail." While this may seem far-fetched, the fact is that computer systems with codes for limited access have been entered by unauthorized but skillful personnel.

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[1]Richard B. Hoffman, Proceedings of Fall Joint Computer Conference, 1966, p. 524.

[2]"Computers Play Cops and Robbers," Business Week, January 15, 1966, p. 138.